Glade Rangeland Management EIS - Appendix H
General Background Information on Project Cumulative Effects
Glade Landscape – Dolores Ranger District, San Juan National Forest
12/15/2014

The purpose of this background information analysis (to be changed to cumulative effects analysis later) is to satisfy the requirements of the Council on Environmental Quality's (CEQ) regulation 40 CFR 1500 - 1508 which directs agencies to comply with the National Environmental Policy Act (NEPA) insuring that environmental information is available to public officials and citizens before decisions are made and before actions are taken. Identifying potential cumulative effects satisfies a portion of the required information by addressing past, present, and reasonably foreseeable future actions that may individually be minor but collectively be significant. To be considered, the effect must add to effects that will occur from project implementation.

The Glade Landscape has been a focal area for a variety of management strategies, techniques, and directions over many many years. Looking at past management helps to define what we see across the Glade today (existing condition). Cumulative effects consider environmental, social and economic effects in the context of our specific project; they can be either positive or negative; they include both indirect and direct effects; and they include both short-term and and long-term impacts.

Directions, decisions, and actions that have influenced management on the Glade come from various levels of influence. Local sentiment, culture and demand have and continue to influence management on the Glade. National direction and demand as provided through the US Forest Reserves and later the US Forest Service have also influenced management across the Glade. What prevails as the "best science" at the time was/is used in managing the Glade. Since "best science" changes over time, so has management methods and objectives. Although influential factors may have begun outside of the project area, the cumulative effects analysis area is bound spatially to the Glade Landscape project area.

Below is a list of past, present and foreseeable future actions for consideration in completing the cumulative effects analysis.

Glade Rangeland Management Analysis			
Historic (Pre-USFS)	**Past (Post-USFS)**	**Present**	**Future**
Multiple-Use			
Individual **tree removal**, limited access and capabilities	Large timber logging camps and portable mills; CCC camps used to control insect outbreaks, improve roads, and watershed conditions	Continued logging to meet vegetation management objectives, use of better technology	Continued logging to meet vegetation and other ecological management objectives
Natural cycles of **forest pest** outbreaks	Large scale timber harvests with objective to reduce risk from bark beetle infestations	Recent bark beetle infestation in ponderosa pine centered at Lake Canyon. Still managing against beetle outbreaks	Increased disturbance factors such as bark beetle, fire, mistletoe, invasive species
No **railroad**	Railroad construction to Calf Allotment area for	No railroad, truck removal of trees	No railroad, truck removal of trees

	timber harvest purposes		
Historic **fires**, minimal or no suppression capabilities	Historic fires, fire suppression, use of prescribed fire	Recent fires such as the Narraguinnep and Bradfield fire; continuation of prescribed fire	Continuation of prescribed fire; longer fire season, increased risk of high severity fires
Few if any **noxious or invasive species**	Introduction of noxious weeds and invasive species such as smooth brome and cheatgrass	Noxious weed treatment; emphasis on natives for revegetation projects	Introduction of new noxious weed species and continuation of native plants use for revegetation; More program emphasis on general invasive species management
Individual **mining** operations	Minimal exploration and development – mostly oil	Increasing oil and gas development; increase in water use and roads systems to support development	Continuing mineral development; seismic operations/shale play
Abundant **beaver**	Beavers extirpated to increase downstream water for irrigation	Gradual return of beaver populations resulting in gradual improvement of riparian areas	Continued beaver population growth and riparian area improvement
Abundant habitat and population of **grouse**	Range vegetation work, hunting, and drought likely resulted in the extirpation of sage grouse and sharptail grouse	Gradual return of sagebrush cover and other habitat improvement in a few areas through management	Possible reintroduction/re-establishment of sage grouse and sharptail grouse should habitat return at large scale
Large **deer** populations	Summer use by deer and spring/fall use by **elk**	Increase in elk populations, continued use predominantly spring/fall	More/longer winter use by elk due to rediced winter snow levels
Subsistence **hunting**	Subsistence and recreation hunting	Recreation hunting	Recreation hunting
Unrestricted **hunting** by both Native Americans and early European settlers	Brunot Hunting Agreement developed with Native American Tribes to allow continued hunting on specific public lands	Recreation conflicts between hunters and grazing permittees (ie. disturbance of animals)	Recreation conflicts between hunters and grazing permittees (i.e. disturbance of animals)
No **motorized travel**	Generally unrestricted cross-country motorized travel	Implementation of travel management restrictions	More intensive travel management
No **roads**	Improved roads to meet needs of vehicles	Roads and trails designated to meet	Intensive travel management to meet

		needs of expanding motor vehicle types and capabilities	needs of increasing public and expansion of motor vehicle capabilities
Individual **recreation** use	Recreating publics increase, use is periodic and seasonal	Recreation use consistent, particularly heavy during holidays, weekends, and hunting season; increased conflicts between recreation use and livestock management (i.e. pasture gates left open, shared use of ponds)	Recreation conflicts continue with increased use
Occasional recreation **campers** and prolonged summer camps by permittees	Long-term logging camp in Big Water Spring area, CCC camps by Glade G.S. and in Sagehen	CCC concept still used via the Southwest Youth Corps (SYC)	Assume some organization exists that resembles CCC and SYC
Pot hunting and indiscriminate **cultural** artifact collecting	Protection of cultural resources via federal legislation	Continued cultural resource protection	Continued cultural resource protection
Homesteading until establishment of Forest Reserves	No homesteading	No homesteading	No homesteading
No **lands** designated State or Federal	Land exchange State/USFS (1940's); most State-owned parcels were not managed for livestock; most grazing was year round – creating less productive land	Newly acquired State parcels actively managed; reduced productivity still evidenced today; gradual improvements noted via increasing ground cover	Gradual improvement via successful range management continues on previous State parcels; Continuing land exchanges/purchases to meet land use plan objectives
Livestock Industry and Range Management			
Unrestricted livestock **grazing**	Custodial livestock management; very high dependence of local operators on public lands	More intensive livestock management via adjustments in livestock grazing to shorter seasons and fewer numbers	Livestock management objectives become more compatible with other recognizes uses such as water quality, recreation, and wildlife
Historic livestock **trailing**	Historic livestock trailing and establishment of stock driveways	Continued livestock trailing and continued use of stock driveways	Continued livestock trailing and continued use of stock driveways
Mixed herds, indiscriminant **breeding**	Herds separated by fences; specialized	Specialized breeding resulting in higher	Continued improvements in

	breeds and genetics develop	livestock weights	livestock genetics – more emphasis on locally produced foodstuffs
"**Public Lands**" do not exist	High dependence on public land use; less stable markets and financial institutions	Socio-economic fluctuations on cattle prices, feed prices	Socio-economic fluctuations on cattle prices, feed prices
Riparian areas considered sacrifice areas for livestock watering	Importance of riparian areas recognized, management begins	Increased emphasis on water quality and riparian management for wildlife habitat; SW willow flycatcher listed; More riparian area improvement projects [i.e. rock streambank work, willow planting, and tire stabilization in riparian areas (east side Brumley)]	Continued emphasis on water quality and riparian area management, climate change may intensify efforts
No livestock **fences**	Extensive construction of livestock fences	Maintenance of livestock fences	Replacement of livestock fences
Few **water developments**	Intensive construction of water developments – mostly spring developments	Maintenance of water developments; intensive stock pond construction; water rights acquisition becomes an issue	Replacement of water developments; increasing tension between State and Federal entities on water rights issues; emphasis on improving existing structures
Diversion of Glade Lake to pond to cultivate the Glade; **natural wetlands/ponds** developed for livestock use	Glade Lake , Ferris and Beef Trail ponds fenced to protect waters for waterfowl and other intrinsic values; conflicts with livestock operators over use of reservoirs	Other water developed to replace use of fenced reservoirs; water rights acquired that emphasizes non-consumptive uses	Continued non-consumptive uses
McPhee Reservoir does not exist	Construction of McPhee Reservoir and purchase of surrounding private land	Creation of archaeological district and wildlife mitigation lands surrounding McPhee Reservoir	Continued emphasis on cultural resource protection and wildlife management in the area
Periodic **grasshopper** and Morman **cricket** outbreaks	Periodic grasshopper and Morman cricket outbreaks	Late 1980's early 1990's grasshopper population increases; 2002-2003 Mormon cricket outbreak	Continued periodic grasshopper and Morman cricket outbreaks with possible increase given warmer,

			drier conditions
Little or no **vegetation treatments** except those resulting from wild and man-caused fire	Vegetation treatments to maintain/increase livestock stocking rates such as rollerchopping, seeding, and herbicide use in shrub types	Vegetation treatments continue including mastication, prescribed fire, post-wildfire seeding, expansion of cheatgrass	Continued vegetation manipulation to meet land use plan objectives
Climate Change			
Periodic **drought**	Periodic drought	Persistent drought	More persistent drought with changing climate; higher temperatures year-long
Few if any **noxious or invasive species**	Introduction of noxious weeds and invasive species such cheatgrass	Slow expansion of cheatgrass	Possible rapid expansion of cheatgrass

MULTIPLE-USE

Multiple uses across the Glade landscape in the 1800's took place at a small scale typical of individual pioneers and included fur trading, hunting, mining, timbering, grazing, even recreation. The designation of the Forest Reserve in 1904 was to regulate multiple uses in order to provide an even flow of water for irrigation, to ensure a lasting supply of timber for wood, and to maintain forage for grazing. The San Juan National Forest was used for multiple purposes well before it was designated a National Forest in 1906. The Glade area was part of the original Montezuma National Forest – the Montezuma National Forest was combined with the San Juan National Forest in 1948. These uses and more exist today and will continue for years to come.

Timber

Past Management: Early logging in the mid 1800's to 1915 was performed using hand saws with logs transported by mules. Individual large ponderosa pine trees were selectively removed but only where access was easy. The arrival of the Rio Grande Southern Railroad improved access. Cutting methods also improved allowing for larger quantities of trees to be removed, lumbered, and transported. Until 1915 an estimated 85% of all timber cut in southwest Colorado was consumed locally. World War I and its aftermath changed this. There was a large pine seed crop produced between 1920-1930 across the forest and specifically on the Glade in 1919, 1925 and 1927. Fires were suppressed to protect the timber resource. From 1920-1930, old growth was removed in shelterwood cuts so that trees were left to seed harvested units. No clear-cutting occurred on the Glade.

In the 1930's large logging and Civil Conservation Corp (CCC) Camps were set up across the Glade at Big Water Spring, near the Glade Guard Station, and in Sagehen (Romme and Bunting, Pg. 32). One of the CCC camps established on the Glade District was for the primary purpose of insect control work in timber stands. Insect outbreaks took place in heavy slash loads particularly where they coexisted with remaining large old trees. This is largely why remaining old trees were removed. Although direction came in 1941 to stop liquidating old growth trees, the direction was not acted upon until 1946.

World War ll (WWII) brought investment capital to the west and in 1942 the federal government classified wood as a critical war material. The Forest Service responded by more than doubling timber production (Romme and Bunting, Pg. 43; Forest History, Pg. 288). By 1962, the annual timber harvest from National Forests had risen to an all-time high (Romme and Bunting, Pg. 43). Timber was the "king" of all multiple uses within the Forest Service and on the Glade District (Forest Retirees 2014, Pg. 5). At its peak, the Glade District was harvesting 120 million board feet annually (compared to less than 20 million board feet today). Trees down to 8 inches in diameter were taken, primarily to remove mistletoe. The last old growth sale on the Glade was in the early 1960's above the Dolores Canyon rim in ponderosa pine.

Ponderosa pine plantations were established in the late 1960's/early 1970's to reduce understocked timber stands – a result of prior intense harvesting (USFS 2007, Pg. 3). Site preparation required competing vegetation to be removed as well as most A horizon soil material as pine prefers mineral soild to get established. Root plowing to remove brush involved stretching a blade between two D-8 tractors and pulled about 1 foot below ground surface. Managers at the time were surprised at the influx of noxious weeds that came-up following treatment. Some plantations on the Glade were placed in oak fields or open meadows where few trees grew to start with for example south of Salter Y, south of the Benchmark turn-off, and in the areas of White Sand Draw and Black Snag Spring. One plantation was placed east of Ferris Reservoir where aspen was pushed up in wind-rows to make way for tree planting (Gary Apple, personal communication 12/14). Many of these plantations were fenced to protect the investment (pine seedlings) from cattle grazing. Some plantations failed because they were placed in marginal timber production areas. The Salter Y plantation was planted with bare root trees and had a 25% success rate. The Black snag plantation was planted with container stock trees and had a 75% success.

By the mid 1980's small diameter trees were being milled, but to make sales cost effective for the loggers, larger trees were also included. It was determined that 25% of a sale had to include trees 16" or larger in diameter to be commercially viable. Post and pole sales provided an avenue for thinning crowded forests. Uneven-aged timber harvest methods were promoted in 1989 to improve overall ecological health by maintaining forests with trees of all ages (Romme and Bunting, Pg. 54). National direction in the 1990's required National Forests to administer ecosystem management principles while at the same time meeting commodity demands. The timber management program addressed restoration, diversity, and health of forested lands that no longer had large diameter trees or snags (previously targeted for removal), lacked age and species diversity, and were ripe for catastrophic pine beetle and/or mistletoe infestations or large scale wildfires.

Conclusion: Timber management direction in the past has changed depending on commodity demand and public sentiment. Some forest stands are currently over-crowded and when combined with warmer climates and the absence of light severity surface fires can result in increased infestations of bark beetles and other agents. Pine bark beetles are currently thinning the forest in areas such as Lake Canyon on the Mair Allotment where approximately 400 acres of infestation were recorded during the spring of 2014. Mistletoe is also prevalent and an indication of stressed trees (stressed from over-crowded conditions and competition for minimal soil moisture). Grasses and forbs diminish beneath dense pine tree canopies given competition for moisture, lack of sunlight, and thick needle litter. These areas have reduced livestock forage capacity, at least until a disturbance occurs to open the stand and promote herbaceous growth.

When the Forest could no longer offer large diameter trees to local mills, as a result of few large trees left and public demand to lower wood fiber production, many mills went out of business. The few that currently exist are able to mill small diameter trees but are not able to keep up with demand. Therefore, other ways to thin stands of small diameter trees have been and continue to be developed including prescribed fire, mastication (mowing), firewood sales, and post and pole harvests.

Fire

Past Management: In the 1900's it is estimated that 50% of woodlands had been seriously damaged by fires that were started from locomotive sparks, stamp mills sparks, deliberate fires and escaped campfires from Native Americans, sheep herders, prospectors, hunters, and cowboys (DuBois 1904, Pg. 18). One specific fire occurred on October 8, 1922 at the head of Long Draw close to Cottonwood Creek. The fire burned for two days and covered 200 acres (Forest History, Pg. 125). Wildfires also set the stage for a flush ponderosa pine seed crop in the 1920's. These years were followed by ample moisture that allowed seeds to germinate. Substantial timbering that allowed sunlight to reach the forest floor and heavy livestock grazing that removed grass competition from around tree seedlings promoted the growth of new seedlings and resulted in stands of small even-aged pine seedlings. After the 1920's, fire suppression increased and wildfires decreased allowing pine forests to grow to even-age dense tree stands. Ponderosa pine stands that formerly burned every 12 to 30 years experienced little if any fire for the next 50 years (USFS Fire Effects Database). The effect to livestock grazing was that closed, dense, tree canopies reduced available livestock forage.

From the 1920's- 1960's, given the value of timber, the sentiment throughout the nation was that all wildfires were bad and therefore fire prevention and/or suppression was essential (Romme and Bunting, Pg. 23). In 1935 the Forest Service enacted a policy called "Out-by-10 a.m." where all fires were to be extinguished by 10 a.m. the day following its reportage. With natural fire occurrence removed as a disturbance factor, artificially high stocking levels of dense small even-aged trees and shrubs resulted in extreme fire danger across the landscape.

The use of fire as a management tool was implemented in the 1970's for clearing brush, slash reduction, and needle cast reduction to reduce fire fuels. By 1974, the US Forest Service publically said that it was no longer in the business of fire control but rather, fire management (Romme and Bunting, Pg. 51). Fire was used on the Glade for resource benefits starting in the early 1970s,throughout the mid 1980's into the 1990's (Mark Tucker, personal communication 12/14). The first prescribed fire occurred on the south slope of Narraguinnep Canyon. The need to expand the use of prescribed fire to prevent disastrous wildfires was discussed, allowing lightening caused fires to burn as a management tool (Romme and Bunting, Pgs. 51-52). Prescribed fire use has declined over the last 10 years or so as favorable burning conditions have declined due to local climate issues.

Prior to the 1900's wildfires in interior ponderosa pine forests were typically low intensity ground surface fires. Stand replacing fires that are carried through the crown of trees would occur maybe once every 30-45 years (USFS Fire Effects Database). The mostly light severity surface fires thinned small trees and maintained large trees in an open park-like setting.

Conclusion: Combined effects of fire exclusion, logging of large fire resistant trees, and dry climate have created closed-canopy tree stands with dense over-stories and ladder fuels. Under these conditions, fires quickly develop into large, high intensity, tree crown wildfires. Evidence of this has occurred through-out the country.

The Glade has typically not had large expansive fires, although much of the conditions described above have developed here. Ferris Rim fire burned 300 acres in the 1970's and again in 1990. The Disappointment fire occurred in 1996 and burned 3,800 acres. Two of the largest recorded fires in Glade history were the Narraguinnep and Bradfield fires of 2009 where approximately 9,500 acres burned within the Glade project area (Dave Grettenberg, personal communications 11/14, Dolores District Files). Although fast upslope winds played a major role in these last two fires, they are examples where intense fires (both in heat, time and extent) have the ability to convert forests back to an early successional stage of grass, forbs and shrubs.

Other ecological consequences of fire suppression in interior ponderosa pine and other vegetation ecosystems include:

- decreased soil moisture and nutrient availability
- decreased spring and stream flows and/or change in flow times
- decreased animal productivity
- increased concentrations of potentially allelopathic terpenes in pine litter (a chemical that excludes other plant species)
- decreased productivity, availability and diversity of herbaceous and woody understory species
- decreased tree vigor, especially the oldest age class of pines, and
- increased mortality in the oldest age classes of trees (greater competition for resources)

A range of variability within woodlands equates to a range in available forage and cover for wildlife and livestock. Foresters today strive for a mosaic of tree age class and species with a balance of understory vegetation. Currently the Forest Service uses both wild and prescribed fire as tools for management.

"The Oak Story": Gambel oak has been a major ecological player in southwest Colorado for a long time, if not forever, and is a persistent shrub across much of the Glade landscape. Oak may be more competitive on the shale soils of the Glade landscape than other similar landscapes in the region. While it has probably always been present, the effects of logging, fire, heavy livestock grazing, and drought over the years have allowed oak to expand and dominate.

Gambel oak has deep roots and an efficient water transport system allowing it to morphologically and physiologically adapt to drought conditions. It also has strong reproductive capabilities regenerating through sprouting as well as seed establishment. Gambel oak is a fire-adapted species responding to fires by vigorous sprouting (USFS Fire Effects Database). Wildfires stimulated oak sprouting but fire suppression allowed oak to persist. These forest conditions occurred during periods of heavy livestock grazing which reduced herbaceous plant competition promoting the spread of Gambel oak.

Heavy logging such as occurred between 1920 and 1980 favored oak production. Foresters were managing a fine balance between managing forest with a high enough basal area to prevent oak expansion (120 basal area) yet low enough to prevent pine beetle infestations (80 bsal area).

Current efforts in forest management typically include strategies to manage and control Gambel oak. Such strategies include successive and repeated prescribed burning, mastication (mowing) either mechanically or use of goats, or perhaps the use of herbicides. Efforts to control oak include two years of repeat burning (or herbicide treatment) followed by two years of intense goat browsing. However, the Glade usually does not have the fuels needed to allow for repeat burning. Gambel oak is not a primary forage species for cattle but is for deer. Cattle will eat oak, should other more palatable grasses

and forbs not be available, but it is considered poisonous to cattle – mainly calves - if their diet consists of greater than 50% oak due to tannic acid poisoning (USFS Fire Effects Database).

Vegetation Manipulation

Past Management: Introduced grass species i.e. smooth brome, crested wheatgrass and orchard grass to name a few, entered southwest Colorado early in the grazing and ranching history. These grasses were the only forage species available in bulk seed for planting for a long period of time. *Bromus inermus*, commonly referred to as smooth brome grass, was introduced into Canada from Eastern Europe. It spread south into the United States and was a popular seeding species used to replenish ranges in the 1930-1960s. *Agropyron cristatum*, commonly known as crested wheatgrass, came from Russia into North America around the 1900's. It was readily used during the drought of the 1930's to help stabilize erosive lands. Many of these treatments are sod-bound today and producing less than one-half of initial forage production.

Cheatgrass, *Bromus tectorum,* was introduced in the 17th and 18th century by settlers from Europe. It was planted in Idaho as it was believed to be a preferred forage species in the late 1890's. Once in North America, it was transported in grain and by animals and began to establish itself on railroad right of ways, fallow fields, and abandoned farms. In the beginning, native plant species kept cheatgrass fairly suppressed, however, continued loss of native species over time allowed for the expansion of cheatgrass. At the time, the "best science" showed the benefits of introducing nonnative plant species out-weighed the loss of soil that would occur while waiting for native species to return. In addition, cheatgrass is a shallow-rooted winter annual grass with limited ability to hold soil moisture and stabilize soils. Cheatgrass is only palatable to livestock during a short period of about six weeks in the early spring and sometimes during winter months and provides no nutrient value to cattle once plants mature. Locally, it is believed that cattle ranchers introduced cheatgrass into McElmo Canyon after over grazing occurred. Although the planting of cheat grass is not known to have occurred on the Glade, its introduction from livestock feeding on cheatgrass infested winter range is likely. Cheatgrass was first identified on the Dolores Ranger District at the Ormiston Point gravel pit in the late 1970's. Efforts were made to try and prevent its spread.

Once well established, introduced species spread and often monopolized areas, reducing plant species diversity and changing natural fire cycles and fire behavior. For example, a natural fire return interval for pinyon-juniper woodlands varies according to site productivity. On less productive sites with discontinuous grass cover, fire intervals are usually greater than 100 years. With the spread of cheatgrass in these locations, the average fire interval can now be less than 35 years (USFS Fire Effects Database).

The immediate benefit of planting these highly adaptive nonnative plants was to stabilize soil and provide forage on depleted ranges. Having large areas (hundreds of acres to start with, more as seeds spread) dominated by nonnative plant species, such as on the Glade, reduces ecological resilience by not maintaining native vegetation that evolved under local conditions. A predominance of nonnatives can upset natural systems such as fire interval and behavior, nutrient cycling, and biomass production. Although the realization of the need to plant native species during restoration seeding efforts came later, the market, technology and demand for natives was not there. Native species have slowly returned and expanded in areas on the Glade where nonnatives once predominated. Many of the meadows within the Glade landscape were comprised of Wyoming big sagebrush and native bunchgrasses. In the late 1940's – 1950's, extensive efforts were spent eradicating Wyoming big

sagebrush across the Glade to promote increased livestock forage production. Repeat treatments of phenoxy herbicides developed during WWII such as 2, 4, D and Diesel removed Wyoming big sagebrush which has not returned to this day (Mark Tucker, personal communication 12/14). This action also contributed to the extirpation of sage grouse and sharptail grouse from the Glade landscape due to the loss of habitat including hiding cover - thus giving their predators the competitive advantage. While some small patches of sagebrush appear to be returning to the landscape, the large expanses that once occurred will not return for some time into the future, if at all. By 1970 this conversion from sagebrush to grass may also have contributed to the Glade becoming primary elk range rather than its previous deer range (Retirees 2014, Pg. 4).

Ponderosa pine plantations of the 1970's were often fenced to reduce impacts from livestock and wildlife, and had been a popular reforestation method for several years on the Glade (Gary Apple, personal communication, 12/14). Some permittees, however, protested the resulting loss of forage capacity. In response, the Forest Service promoted vegetation manipulation projects such as chaining, rollerchopping, and seeding to increase forage production and to offset forage losses. These treatments uprooted (chaining) or chopped (rollerchopping) pinyon pine and juniper trees. The result was a temporary forage production increase, loss of trees and the accumulation of large debris piles. In some areas brush encroachment resulted and in others nonnative grass species were seeded occurred.

Conclusion: As a result of past vegetation manipulation on the Glade landscape, large expanses of non-native grass species predominate (now thousands of acres). Smooth brome and/or Kentucky bluegrass are perhaps the most dominant grass species found on the Glade. Both have been introduced. Cheatgrass occurs in small patches, usually on the warmer dryer benches above Bradfield Bridge. It does appear to be moving upward in elevation and gets established where livestock , wildlife, and recreation use trample or overgraze and create open ground for seed establishment. Today the demand for native seed has grown into a large-scale economically viable business across the United States. Most restoration efforts on Forest Service-administered lands these days, require the use of native seed. The Bradfield and Narraguinnep burn areas were seeded with native species and a sterile non-native species. Both seeding efforts were successful and resulted in improved forage production and reduced noxious weed establishment.

Chained or rollerchopped areas typically consisted of pinyon pine, juniper trees and Gambel oak. Many of these areas responded to these treatments by the prolific sprouting of oak. In some cases, this improved sharptail grouse habitat by increasing shrub diversity. The harvesting of Ponderosa pine trees across the Glade also resulted in favoring Gambel oak. Once established, oak is difficult to control as it is stimulated by cutting and infrequent burning. Repeat hot burns during the fall and/or the use of herbicide has shown to be effective in controlling oak brush.

Wildlife

Past Management: Historically, wildlife on the Glade consisted of a much different variety than occurs today. Grizzly bear, wolves, bighorn sheep, sagegrouse and sharptail grouse were species extirpated over time (Forest History, Pg. 161). The enactment of game laws began in the early 1900's. Elk were reintroduced to Southwest Colorado in 1911, again in the 1930's, 1970's and 1980's (Retirees, personal communication 1/15). Turkeys were also transplanted in 1970's and 1980's. They had been abundant on the Glade historically but co-mingled with domestic chickens in the 1900's and died from disease transmission. Turkeys were first reestablished in Dry Canyon.

As pioneer settlements expanded and ranges became crowded, most stockmen disputed game restrictions and openly advocated extermination of predators. The Forest Service and Colorado Department of Fish and Game supported the stockmen and in 1905, the Forest hired trappers to kill wolves. Predator elimination resulted in unnatural increases in elk and deer populations as well as other wildlife.

Big game populations continued to build through the early 1940's with a peak in deer numbers around 1946 (Forest History, Pg. 291). The Glade was considered deer range in the 1960's but by the 1970's had shifted to primary elk range (Retirees 2014, Pg. 4). Since deer tend to be browsers consuming forbs and shrubs and elk prefer grasses, this shift in species was likely due, at least in part, to the extensive treatment of sagebrush on the Glade and its conversion to grass-dominated sites in meadow areas.

The Dolores River was a cool water trout stream in the early 1800's. Originally, the Dolores River fluctuated as a natural stream with high spring flows, lower summer flows, and periodic flooding during summer monsoonal rains. This provided excellent habitat for native trout that required high flows in the spring to scour spawning grounds. A large tunnel was constructed to divert water from the river for irrigation purposes in the late 1800's. The dewatering of portions of the river resulted in a loss of riparian vegetation as well as fish and wildlife habitat. The stream was converted to a warm water fishery with chubs and sucker fish. Construction of McPhee Dam resulted in the return of cool water flows to the river below the dam. This occurred for several years at which time it was felt the stream had characteristics of a 'gold medal water' with campground and fishing facilities built to provide for the anticipated influx in anglers. This worked for a while but prolonged drought and increased demand for water diminished flows.

The construction of McPhee reservoir between 1980 and 1985 inundated lands that provided forage for local livestock and wildlife populations. While the area supported resident deer herds, it was primarily winter range for elk. Much of the land surrounding the reservoir today falls within the Sagehen Allotment and is managed for wildlife forage, particularly winter range. The reservoir also shifted big game migration patterns and re-routed livestock entering the Forest.

Two primary stock driveways cross the Glade: one directs cattle between Groundhog and Bradfield Bridge; the other is mitigation for McPhee Lake and routes livestock back and forth from Groundhog to below McPhee Dam then across Sagehen to the divide between McPhee and Narraguinnep reservoirs.

Desert bighorn sheep and river otter were reintroduced along the Dolores River in 1987 (Dave Sanford, personal communications, 12/14).

Conclusion: The loss of natural predators such as wolves and grizzly bears resulted in an increase in prey species like deer and elk. Humans now act as the primary predator for many species.

Elk are expected to continue as the primary ungulate across the Glade given the predominance of grasses. Their current use of the Glade is as spring and fall transition range. Elk move from BLM lands, private cultivated fields, and the Dolores Canyon where they winter, northeast to private and state lands between Lone Mesa and Groundhog for the summer. This minimizes competition with livestock on the Glade for forage during the summer months. Forage needs, however, cross over during spring and fall. The popularity of hunting on the Glade results in heavy use of roads and numerous camping locations. These results in the trampling and removal of vegetation and can alter livestock movements by camping near water sources or leaving gates open.

The construction of McPhee Reservoir altered game migration patterns and removed forage availability. To compensate for this loss, lands adjacent to the reservoir (Sagehen Allotment) were designated as mitigation for wildlife.

McPhee Dam also altered stream flows below the dam. Cottonwood galleries that once dominated the river bottom were removed to make way for farm land. Now that most of those farms are gone, cottonwood trees are returning. Current management objectives include a mix of open large meadows, desne willows for Southwest willow flycatcher habitat, and patches of cottonwood trees.

Transportation

Past Management: When the Montezuma National Forest was established in 1905, the only way to get into the Glade Ranger Station from Dolores was over a trail with a saddle horse or by foot. By 1910 the trail had increased to a two-track wagon road. When oil exploration began in 1926, the wagon road was improved to accommodate trucks. The New Mexico Lumber Company established a mill on the Dolores River and after transporting logs off the mountain using railroad and steam equipment, they began hauling with trucks (USFS 1935, Pg. 5). One of the primary jobs of the CCC in 1933 was to improve the road system which was primarily paid for with timber sale receipts.

Seismic exploration and mineral development in the early 1970's resulted in road development. The construction of McPhee Reservoir resulted in improved road conditions. During this period there were shorter hunting seasons, less people and fewer 4x4 vehicles. Roads weren't used as much and dirt roads would grass over between seasons of use. Since then, hunting seasons have been lengthened, the number of people using the Glade has increased and the use of 4x4 vehicles, including ATVs, has grown exponentially.

Types of off-road vehicles have expanded to include dirt bike motorcycles, all-terrain and utility vehicles, and mountain bicycles. With the onset of such vehicles, road and trail expansion increased exponentially. To minimize resource damage from transportation, a 2013 travel management plan was recently developed for the Boggy-Glade landscape restricting motorized travel to designated routes. This was based on National Forest Service direction received earlier in the 2000's.

Conclusion: The improved transportation system on the Glade meant that grazing permittees were less apt to live with their livestock but travelled back and forth from home instead. Daily herding and management of livestock was reduced. Livestock that are not frequently herded into wooded and brushy areas to obtain feed, spend an inordinate amount of time in parklands, wetlands and riparian areas where feed is easily accessible. These areas are the first to get over-grazed. To exasperate this issue, many stock ponds were constructed in grass parks where equipment could be transported easily for purposes of construction and maintenance. This of course attracted livestock to these areas not only for feed but for water as well. Parks, wetlands, and riparian areas show more damage from historic livestock grazing than any other vegetation types on the Glade.

Two allotments (Long Park and Brumley) on the Glade currently employ full time riders to maintain regular consistent herding of livestock. Cow camps are permitted to allow grazing permittees/riders to stay with their herds to provide better management. Improved roads also shifted livestock operations so that most livestock these days are trucked, not herded, on and off the Forest. The expanded road system also increases access for exotic species introductions. Seeds from invasive weed species such as knapweed and musk thistle often spread via motor vehicles.

Land Ownership

Past Management: The Homestead Act of 1862 promoted settlement of prime rangelands usually along streams and rivers. These settlements removed lands from open grazing and tied-up much needed winter rangelands (Forest History, Pg. 46). These lands were later used as base property for grazing permittees on the forest, a requirement for permit acquisition.

Federal lands within Colorado were considered public domain and used as such. When Colorado became a state on August 1, 1876, it forfeited any claims to federal lands. Two sections of land – sections 16 and 36 – were granted to the State to be used for generating funds for schools and roads. These lands were scattered among federal lands and often occurred as isolated parcels. In order to reduce checkerboard ownership patterns and to promote large continuous expanses of public land, many of the parcels were exchanged in the 1940's and became under federal management. Most of these parcels, however, were in such poor condition due to over-grazing that they were rested in order to improve conditions.

Conclusion: It is because of the Homestead Act that much of the land along the Dolores River in the Sagehen Allotment was private land and hay crops produced. Since that time, the State Division of Parks and Wildlife has acquired several private land parcels and converted them back to river bottom vegetation for wildlife habitat.

Evidence of poor range conditions from historic over-use remains on several old State Land parcels today.

Land Ethic

Past Management: Without laws, management, or restrictions of any kind, lands across the west were originally used by everyone who dared venture that far. The primary use of lands were for sustenance and commodity purposes such as lumbering, cattle grazing, and mining. As settlements increased, the use of resources increased and damage started to occur. The demand on resources was not sustainable.

In 1933, Aldo Leopold, a former Forest Service employee, developed what became known as the 'Conservation Ethic' (Romme and Bunting, Pg. 35). He enlarged the boundaries of the ecological community to include soils, water, plants, and animals, or collectively 'the land'. According to Leopold's land ethic, "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community". The American public started showing interest in the balance of uses on National Forests in the 1960's and became concerned with impacts from mining, timber harvest and livestock grazing. The passage of the National Environmental Policy Act (NEPA) in 1969 required all federal agencies to disclose to the public all potential environmental effects from proposed actions. The passage of the Federal land Policy and Management Act (FLPMA) and the National Forest Management Act (NFMA) in 1976 stressed the Forest Service's mission to protect the health of National Forests promoting true multiple-use management rather than emphasizing commodity production. The 1990's ushered in the environmental movement with the number of organized environmental groups skyrocketing nationally (Romme and Bunting, Pg. 53).

Originally (1910) the definition of carrying capacity for land used by livestock was defined as the largest number of animals that range grasses can support and still grow back the next year (Romme and Bunting, Pg. 30). As Leopold's land ethic swept across America, nationally the Forest Service was held accountable for a carrying capacity that went well beyond the growth of grass to include soil stability,

nutrient cycling, native species composition, and erosion control – those factors that today define "ecological resilience".

The Public Rangelands Improvement Act (PRIA) was enacted in 1978 and defined the current grazing fee formula and established rangeland monitoring and inventory procedures to be used by Federal agencies. The grazing fee formula remains the same today which results in a cost per HM of around $1.35 (it fluctuated up to $1.47 at one point in the past 20 years but never drops below $1.35). At this low cost, permits remain in tremendous demand. The Rescission Act of 1995 required each National Forest to establish and adhere to a schedule for completing NEPA analysis and decisions on all grazing allotments within a 15-year period. Adjustments to this schedule have been ongoing.

Conclusion: Today, ecological resilience is defined as "the capacity of a system to absorb disturbance and reorganize itself without irreversibly losing its desired composition and function…" (*Understanding Resilience: A Literature Review* by Herrick Fox). This requirement plus the need to disclose environmental effects, has resulted in the need for more quantifiable data collection, the ability to explain in greater detail the cause: effect relationship between livestock grazing and the land, and the expectation for more intensive livestock management.

LIVESTOCK INDUSTRY AND RANGE MANAGEMENT

Past Management: The livestock industry has a long history on the Dolores Ranger District. Scattered small herds of horses and cows came during the early fur-trading and prospecting days of the 1800's. Ranching and farming in the San Juan National Forest is thought to have been established by the 1860's-1870's (Tucker 1996, Pg. 1; USFS 1925, Pg. 4). Life on the Glade is described in an excerpt from Pg. 88 of Forest History written by R.B. Dunham which states, "A fort was built about 1884 mainly to protect John Bowen's family, his wife and 3 children, who had a permanent camp there [Narraguinnep Flat]. The men from Plateau Camp and Dunham had about 100 head of horses on the glade about 5 miles west came in to help….The men in this district had about 10,000 head of cattle, there was grass up to the stirrups most every place and plenty of water. We never worried about drought".

Early cowboys felt there was no end to the grass in this area. Many of the native bunchgrass parks on the Forest were cut for hay by both Native Americans and settlers and fed to local livestock or sold commercially to local mines (Forest History, Pg. 129). Once mines closed, ranchmen raised larger cattle herds as a means of disposing of their hay (Forest History, Pg. 130). As livestock herds increased, demand for hay increased and lead to the development of irrigation systems. The first irrigation system that watered a major portion of Montezuma Valley was constructed in 1886 (Forest History, Pg. 61). This helped to sustain year-round grazing operations. Also at this time large bands of sheep were being herded across the Four-Corners region mostly from New Mexico (Forest History, Pg. 139).

Prior to the development of the Montezuma Forest Reserve, ***season-long grazing*** predominated where livestock were allowed to graze any place on the summer range until feed became depleted and forced them to move in search of additional forage. Grazing a particular meadow or pasture occurred through the whole grazing season which was generally 8-9 months. Grazing would have been continuous i.e. year round, except that snows pushed livestock off summer ranges. Livestock herds were said to follow snow melt up to the high country in the spring and snow fall down to the low country in the winter (Freeman 1958, Pg. 112). During winters of little or no snowfall, livestock grazed the Glade year-round.

This type of use resulted in reduced populations of highly productive bunchgrasses which substantially reduced forage production and increased bare ground leading to soil erosion and loss.

The peak of unrestricted grazing occurred about 1890 but continued for some time. Adverse conditions took place, resulting in hillsides turning to dust heaps and serious gully and sheet erosion taking place (particularly in higher sheep ranges). Forage plants were lost and undesirable weeds and annuals took their place (USFS 1935, Pg. 6). These were considered the results of too many animals on the range that used it before it was ready.

By 1905, when the Forest Reserve was established, the average grazing season for sheep was 6/16-10/15 in the high country (aspen, spruce, fir, meadows) and 4/16-11/30 for cattle in the low country (ponderosa pine, pinyon pine, juniper, oak brush). By 1950, cattle on-dates had been pushed back to May 1st and after 1960 it was June 1st (District files). Ranges were over-stocked which was made worse by large herds of outside cattle shipped in from New Mexico and Texas. Ranchers continued to settle Montezuma County, increasing the demand for livestock forage while tying up fertile ground for settlements.

When the Forest Reserve was established, one of the first tasks was to establish grazing allotments. Livestock operators met with agency personnel to mark on a map where they ran their herds. Permittees whose herds overlapped the same area were combined into Grazing Associations. Those permittees were then assigned a piece of ground by which they were allowed to graze (USFS 2007, Pg. 1). As the number of permittees dwindled, mostly through buy-outs, Grazing Associations were replaced by Community Allotments. Currently the only community allotment in the study area is the Glade Allotment with three permittees.

By 1906, accountability for grazing on livestock allotments began by the Forest Service prosecuting violators for over-grazing or trespass (Romme and Bunting, Pg. 19). Fees for grazing were also imposed which started generating revenue. Grazing Boards were established to consult with Forest Service personnel in determining initial stocking numbers for each allotment. By 1910 a grazing permit system went into effect with carrying capacities determined through ocular estimates. Carrying capacity was defined as the largest number of animals that range grasses could support and still grow back the next year (Romme and Bunting, Pg. 30). Most allotments remained heavily grazed with stocking numbers on the high side since this definition of carrying capacity was based on economic efficiency and full use rather than biology (Romme and Bunting, Pg. 30). The Forest Service has been adjusting numbers ever since, based on the most current scientific methods and data. Many of the early tools of livestock management are still in use today including salting, seasonal use, actual use monitoring, adjusting grazing seasons, and changes in the class of stock (USFS 1935, Pg. 6). The Forest Service made ten-year permits legal agreements with permittees in 1926 (Romme and Bunting, Pg. 30), a privilege that in many cases has been handed down from generation to generation.

It is believed that the period of time between 1904 and 1920, was when range conditions deteriorated rapidly (Forest History, Pg. 150). Forest Service came to understand by the mid 1920's that erosion control depends on several factors:

- Over grazing must not take place
- Too early grazing must be avoided
- Deferred and rotational grazing should be practiced
- Proper control and distribution of livestock is necessary

By the 1930's range management was starting to be understood as a complex science when managing for watershed protection, erosion control, game , and livestock and timber production. Along with reducing livestock numbers, additional management included better handling methods, adjustments to season dates, development of uniform utilization guidelines, management of trespass cattle and horses, and the construction of range improvements. The sheep industry was being reduced given market conditions; long cross-country sheep trailing was gradually discontinued.

It was assumed that once all these management techniques were in place, rapid improvement of range conditions would occur. However, progress was painfully slow and in 1932, the drought years began. It was soon discovered that stocking rates were set during wet years and therefore, remained too high for drought conditions. If not for range improvements, it would have been necessary to totally remove most of the cattle herds from the summer range (USFS 1935, Pg. 8).

Once the Montezuma National Forest started restricting forage utilization, (1950's and 1960's) a ***deferred grazing system*** began. Livestock were allowed to graze each pasture every year as long as there was a period of non-grazing during part of the forage growing season. This meant cattle were required to keep moving and were not allowed to stay on the same pastures all summer. This system also allowed forage vigor recovery during the growing season meaning plant and root re-growth occurred.

The construction of range improvements, such as fences, springs, ponds and water troughs, were also used to manage livestock. Early improvements were financed through Association assessments on permitted livestock and were designed and maintained by Forest Service personnel and the Civil Conservation Corp (CCC). Another infrastructure build-up occurred during the 1960's-1970, intensifying management to accommodate high stocking levels. The passage of the Public Rangelands Improvement Act (PRIA) in 1978 promoted permittees' acceptance of the job of range improvement maintenance, since they felt they could do the job cheaper than the Forest Service. Between 1959 and 1962, there was a national emphasis in the Forest Service to conduct range analyses that consisted of mapping and evaluating dominant species, vegetation type, range trend condition rating. This data was converted into Animal Months (AM) which at the time was synonymous with Animal Unit Month (AUM) and was based on the average Herford or Herford/Longhorn cross or Angus cow (Mountain 2006, Pg. 2). An AUM, or the average amount of forage consumed by a cow and her calf in one month, was established based on the average size of the above breed of livestock. This "average size" was a 950 lb. cow and her 380 lb. calf. The construction of fences separated livestock into allotments and allowed permittees to tailor their livestock breeding program to favor whatever genetics they wanted. Since more weight on the hoof meant more money at the sale barn, improved cattle breeding resulted in larger animals that can now weigh as much as 1340 lbs. for a cow and 600 lb. for a calf. This means the average amount of forage consumed by a cow and her calf in one month (AUM) has increased substantially since original stocking levels were set.

During the 1960's and 1970's, a national push was made to have all allotments managed under a ***rest-rotation grazing system*** (Hormay 1958). Each grazing allotment was required to have a minimum of three pastures - preferably more - prior to implementing the grazing system. During the grazing cycle, each pasture was periodically rested from livestock grazing for a full year (12 consecutive months) rather than just part of the growing season. Deferred rotation grazing was applied to remaining pastures within the allotment.

Research showed range conditions improved when plants were allowed to complete one full growing cycle every 3-5 years. The philosophy at the time was that with more intensive management through fence construction, reservoir and spring development, salting, vegetation improvements, and other improvements, each allotment could be managed under rest-rotation so that the rest would improve range conditions and at the same time allow for increased livestock numbers.

Over the next 10 plus years, temporary increases in livestock numbers (via grazing permit modifications) were granted while management was intensified. It is important to note that during this period of forest management (1960's-1970's) climate was relatively wet. Forage production was measured based generally on Kentucky bluegrass, a grass species that responds positively to moisture. The result was likely over-inflated capacity estimates. In addition, temporary livestock increases were often granted prior to the completion of one full grazing cycle which was before range conditions could be adequately assessed (Mark Tucker, personal communications, 12/14).

By the late 1970's and early 1980's, it became obvious that the rest-rotation grazing system was not working on most allotments across the Glade (and the Forest). The primary reason was the elevation difference within a single allotment which could range from 6,900 to over 9,000 feet. Lower elevation pastures were usually ready to be grazed earlier in the season than higher elevation pastures. Therefore, the flexibility needed to rotate a rest through all pastures plus adjust entry dates on pastures to be grazed was not possible. In addition, fluctuating drought conditions were regularly cycling through the area reducing widespread forage production and requiring rested pastures to be used to sustain livestock numbers for a full grazing season.

By 1974, rest-rotation grazing systems were being changed into modified systems involving a type of deferred grazing with or without periods of rest. Therefore, the Forest Service was directed to evaluate each allotment whether to reduce, maintain, or completely cut the temporary increases in livestock numbers previously granted. About 1980, the Dolores Ranger District decided to convert all temporary increases to permanent. This decision maintained current stocking levels that in many cases, still exist today.

Years of forage production and utilization data have been used to estimate appropriate stocking levels based on vegetation types on suitable livestock ranges. Stocking levels also take into consideration the philosophy of taking half and leaving half, where a minimum of 50% of the forage produced on any given year should be left for soil stability, wildlife habitat, nutrient cycling, and other resource needs. The half that is taken does not distinguish between domestic and wild animals. Proper utilization levels, however, are often set based on desired conditions and key forage species and may be less than 50%.: Ongoing resource concerns across the Glade landscape as a result of historic grazing use can be traced back to several common management issues such as poor livestock distribution; high stocking rates set during periods of wet climate (when forge production levels were inflated); early and long historic seasons of use; lack of sufficient and effective herding and salting; and a disproportionate use of meadows and parklands (often in association with reservoirs).

Grasses start growth from dormant buds or over-wintering tillers. Growth occurs in the spring when soil temperatures become warmer and daylight length is extended. If the bud/tiller is grazed during this growing period, growth stops. Every time new buds/tillers are initiated, carbohydrate reserves stored in the roots of the grass are drained causing the grass to loose vigor and root mass. Some plants green back up in the late summer and early fall, but with year-long grazing, these plants too would have been grazed. If this happens repeatedly every year, ultimately, the plant will die.

When early grazing without restriction historically occurred, native plants were grazed repeatedly (high numbers of livestock) during their growth periods (going on too early, not moving, and staying too late). This started a chain reaction resulting in the loss of the plant, loss of ground cover, and consequently loss of soil stability. Today we monitor for "range readiness", the point in the spring when grazing may begin under a specific management plan without permanent damage to vegetation or soil. If ranges are repeatedly grazed before they are ready, then plants are weakened, growth is delayed, time of maturity is advanced, seed production is decreased, and seed fertility is reduced.

Although stocking levels were reduced by 58% between 1919 and 1934, severe range damage had already occurred. It is well documented that original impacts upon pristine sites are usually the most severe and often the hardest to fix (Fleischner 1994). Stocking levels have been reduced from 35,793 AUMS in the 1940's to 19,575 AUMS today. Average grazing seasons have been reduced from 187 days to 150 days, and the initial livestock entry date is now two months later than when seasons were first established (from April to June).

Livestock ranges on the Glade have improved however, since range science was first applied. In general across the Glade, bare ground has decreased, forage production has increased, downcutting of streams and swales has slowed or stopped, and native plant species are slowly returning in some areas. While improvement has been made; when combining lingering historic impacts, current management, and the potential for prolonged drought conditions; ecological resilience remains tenuous. Although some indicators of restored range health can take a very long time to become evident (i.e. species conversions, healed streambanks, biological crust formation), several pastures or entire allotments appear to be "stalled out" in their path to recovery. Others, while not at desired condition, continue to show progress in that direction. Still others , because site potential has changed, will never reach range health as it was originally (See analyses for each allotment).

Vegetation treatments to promote livestock forage production were a common practice in the 1960's – 1980's. While the desire is to maintain these improvements, a lack of funding often limits opportunities. Many of the range structures built in the 1930s as well as those constructed in 1960-1970, whether maintained through the years or not, are now warranting replacement. This is extremely expensive given today's labor and material costs. For example, the philosophy of fencing every riparian area to protect against livestock impacts remains a costly approach when considering 2014 costs of over $6/linear foot for fence construction labor, fence materials costing nearly $18,000/mile and additional costs for resource surveys and environmental assessments.

CLIMATE CHANGE

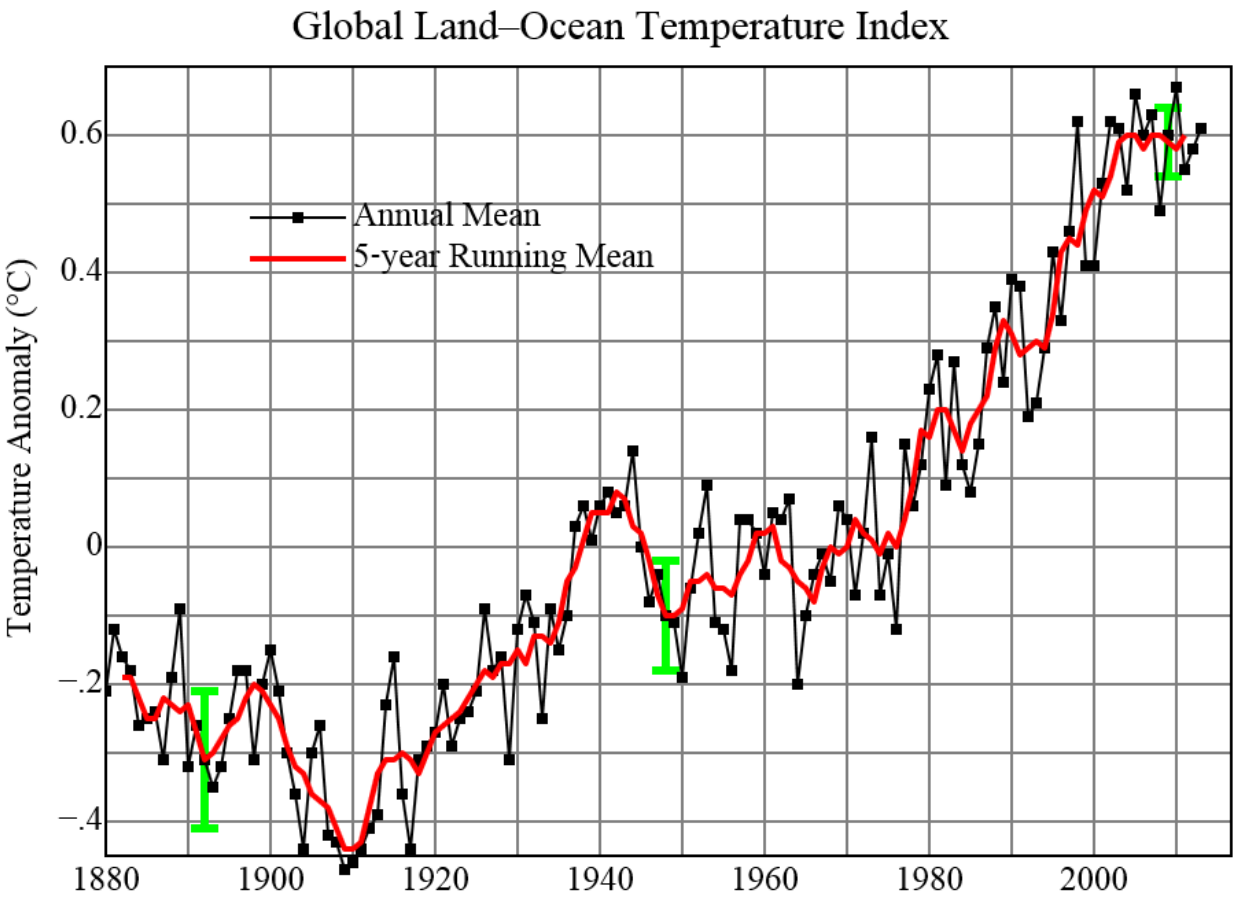
The principle components of "climate" are the air temperature and precipitation that characteristically prevail in a region. Although our understanding of climate change in the planning is evolving, we do know that the observed temperature record in southwest Colorado shows average annual warming of about 2 degrees Fahrenheit over the past 30 years. Additional warming is predicted for the future (Western Water Assessment 2008). In comparison, the observed precipitation record in Colorado does not show long-term trends in annual precipitation. This is due to the wide variations in elevation and complex terrain of Colorado, which complicate past and future precipitation trend analysis (Western Water Assessment 2008).

Past Conditions: Drought in southwest Colorado has been recorded as far back as the winters of 1900 and 1901 but likely occurred before. There was so little snow on the Glade that cattle often wintered all year. Springs across the Glade nearly all dried during the summer of 1901. Water pumps were put in at a well on the Glade and also on a well at Doe Springs. Livestock that could not water at these places were taken to Fish Creek which was the nearest water. Cattle around Calf Creek and Hoppe Point were driven to the Dolores River for water about three times a week (Forest History, Pg. 158)

The early 1930's drought was described as some of the driest years that ever occurred in southwestern Colorado. A local resident described it as follows: "There was very little snowfall during the winter, all of the mountain roads were open to automobile travel all winter, and what snow we did have, went off early; when the snow went, very little water resulted from its melting, as many of the large draws and canyons did not run at all. In April and May we had cold weather with north winds which took out most of the moisture that was in the ground. By the first of July all the stock water was gone excepting in the springs and a few reservoirs." (Forest History, Pg. 95).

The 1950 drought was declared by old-timers to be much worse than the one in the 1930's because it was more localized to southern Colorado and northern New Mexico. Many speculated that the 1950's drought with its unusually high and erratic winds was tied to uncontrolled cloud seeding projects disrupting the normal flow of air currents and robbing areas of normal precipitation (Forest History, Pg. 296). Winds, particularly in the spring, increase snow melt and dry soils rapidly at a time when grasses need moisture to grow.

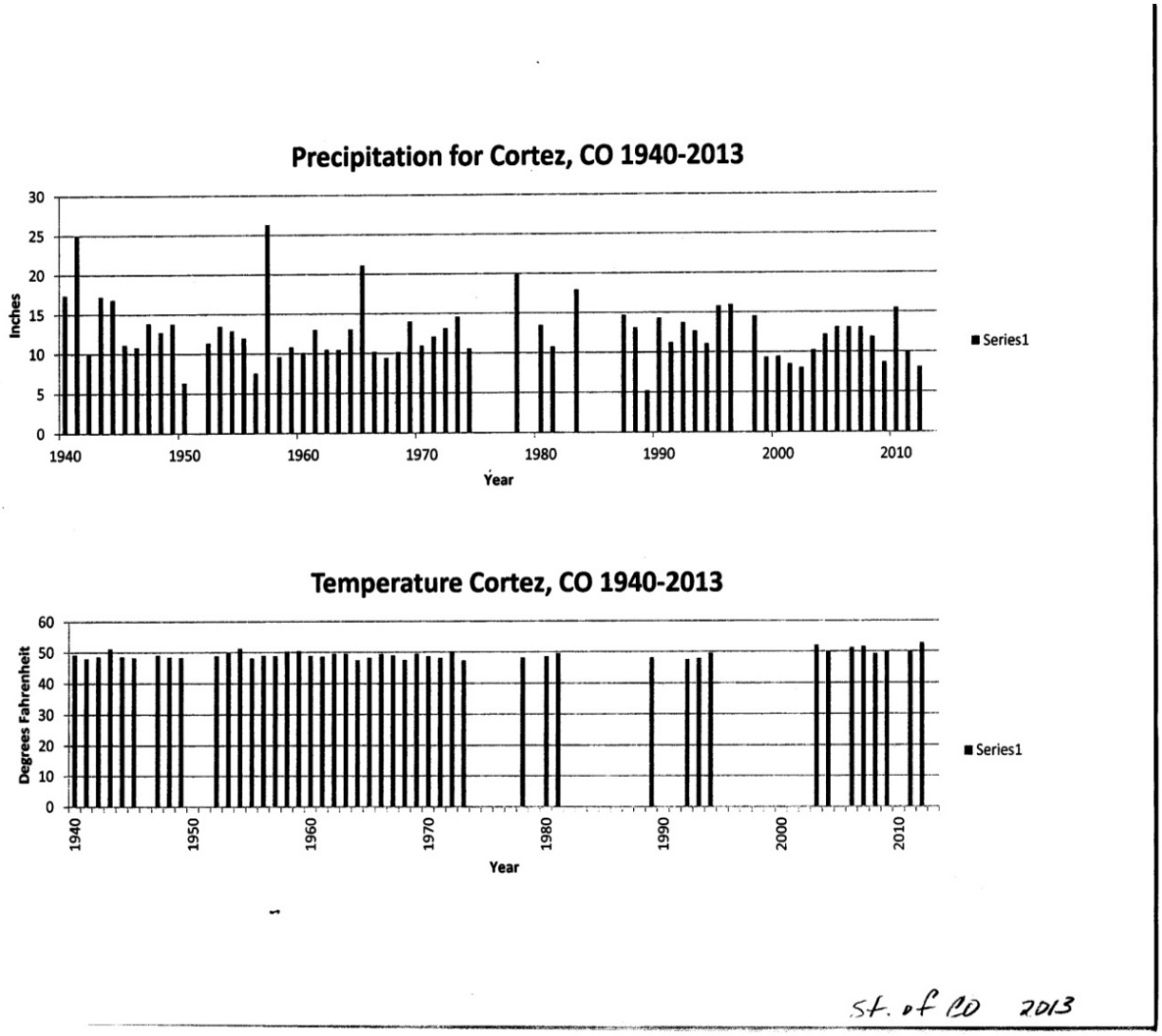
The analysis of climate change is now required as part of environmental assessments for the Forest Service and is defined as the observed century-scale rise in the average temperature of earth's climate system (Wikipedia.org 11/3/2014). The Intergovernmental Panel on Climate Change (IPCC) stated in their 2013 report that "Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes." - IPCC AR5 WG1 Summary for Policy-makers.



Global mean land-ocean temperature change from 1880-2013, relative to the 1951-1980 mean. The black line is the annual mean and the red line is the 5 year running mean. The green bars show uncertainty estimates (Source: NASA GISS http://data.giss.nasa.gov/gistemp/). An increase in temperature over time is evident with a rapid consistent escalation apparent since 1975.

The mean annual precipitation for the Cortez area from 1940 to 2013 was 12.67 inches (ranging from 5.23 to 26.34 inches). Fourteen out of these 73 years had less than 10 inches precipitation with half these years occurring since 2000. Prolonged drought in the southwest has prevailed during the 2000's.

The following chart shows temperature and precipitation in the region. The area has experienced warm/dry periods with 'drought-like' conditions cycling through about a third of the time. The area also experiences sporadic precipitation events- usually heavy monsoonal rainstorms. Winter snow accumulations can vary from sparse to several feet.



Conclusion: These weather patterns can have profound effects on range condition including forage production, ground water re-charge, soil moisture, spring water flow, stock pond replenishment, plant species survival, and more.

Increased temperatures combined with decreased precipitation can lead to lower plant productivity which in turn decreases vegetative ground cover and litter. Low ground cover exposes soil to wind and water erosion and expedites soil moisture loss through evaporation.

Deep-rooted grass species are desirable given their ability to stabilize soil, hold soil moisture and produce ample plant material for ground cover and litter. Well-formed bunches of grass also capture water and prevent rapid evaporation from the ground surface. When deep rooted grass species are well-formed and well-distributed, typically good hydrologic function exists. Deep-rooted plants,

however, require soil moisture to penetrate the ground surface at a depth to reach their roots. Prolonged drought can cause a decline in deep-rooted plant species.

Mid or short-rooted grass species rely on ground surface water for sustenance. These species are favored over deep-rooted species when conditions include wind, higher temperatures and less soil moisture. Short-rooted species are less able to stabilize and hold soil, can't access as much water, can't store as much water in their leaves, and won't produce as much litter as deep rooted species. Bare ground spaces often predominate between shallow rooted grass species. Mats of grass become broken and water runs between the mats forming rills and can erode with each precipitation event. Bare ground also provides a median for nonnative invasive species establishment.

In order to minimize continued drying of soils, particularly during drought conditions, it is important to maintain ample ground cover to hold soil moisture whether that is vegetative litter, mat forming plant species, or biological crusts. It is also important to maintain deep-rooted species and to expand their existence where-ever possible. Proper livestock management to allow for these conditions is important.

Prolonged drought may affect aspen woodlands as well. Dry climates can affect hydrology so that aspen stands become too stressed to persist, transitioning into a shrub-dominated community of oak, serviceberry and/or snowberry. A loss of aspen on the landscape would result in a loss of forage for livestock and wildlife as this vegetation type is one of the most productive on the Glade yielding up to 2000 lbs. of forage per acre (as opposed to 600 lbs. per acre in mountain shrublands dominated by oak).

Ponderosa pine and Gambel oak are deep rooted and well established species on the Glade. They are also drought-tolerant species and are likely to remain or expand on the landscape given prolonged dry conditions.

Coupled with poor forage conditions, there is often a general scarcity of water for cattle under drought conditions since ponds and reservoirs depend on surface water from winter snow and rainfall to fill. Ranchers with permits on the Glade rely on springs and reservoirs to help distribute and water livestock. A lack of adequate winter snowpack results in insufficient water in many reservoirs and low water flows at springs. Although monsoonal rains can help to replenish, it usually takes deeper ground water to support springs and many reservoirs. The lack of water in some pastures renders them unusable for cattle or requires the hauling of water by permittees. Cattle depending on small, shallow, muddy water holes often have reduced health and loss of condition and weight. As drought conditions persist, water conservation practices become crucial. Livestock pressure on water sources will increase as will the need to maintain properly functioning structures with protected water sources.